SUCCESSFUL 432 MHz

EME ANTENNAS

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301 Industrial Way

San Carlos, California

AS-49-8

SUCCESSFUL 432 MHz EME ANTENNAS

by Joe Reisert, W6FZJ

This note will mainly focus on 432 MHz EME antennas. Before reading, it is recommended that you review the considerations in AS-49-5, "Successful 144 MHz EME Antennas" since many of them also apply to 432 MHz.

All the antennas in the photos cannot be considered successful (one or more two-way EME QSO's) since two antennas are incomplete at this time (WA6EXV and WØOQI). However, their construction will provide good design ideas. Furthermore, all the successful antennas produce echos, thereby providing a built-in self-test!

The trend on 432 MHz EME has been to build an antenna capable of producing echos. Most stations are using an antenna-mounted preamplifier with 1.5 dB typical noise figure and 500 watts of RF at the antenna. If these two objectives are met, echos will be possible with an antenna gain of 23-24 dBi. (Decibels above isotropic are used in this note. To reference to a half wave dipole subtract 2.14 dB). Therefore, a total end-to-end gain of 46-48 dBi is the <u>minimum</u> necessary for EME QSO's. As pointed out previously, it is not necessary to have this minimum gain at one end if the sum of the sum of gain of both stations in the schedule is at least 46-48 dBi. While some horizon gain QSO's have resulted on 432 MHz they seem more elusive than at 144 MHz. This is probably due to the fact that most stations using the horizon for gain have not used antenna mounted preamplifiers thereby not taking advantage of the lower sky temperatures available at 432 MHz.

432 MHz EME offers a wide area for antenna experimentation. It is probably the highest frequency where Yagis can attain acceptable gain. At the same time, it is the lowest frequency where a parabolic dish of reasonable size diameter is practical. Therefore, serious consideration should be given to the optimum choice for each individual.

The first consideration should be the mount. If tropospheric and meteor scatter work are contemplated, an AZ-EL mount will probably be favored. If not, the polar mount is very attractive. Another consideration should be polarity. On 432 MHz, Faraday rotation is generally quite slow (typically 2 - 4 hours between peaks). Therefore, some consideration should be given to circular polarization or polarity rotation. Circular polarization hasn't been used very much on 432 MHz since many stations are using linear arrays which are not easily converted. The Yagi array is more difficult to rotate in polarity since it has length. The dish is quite easy to handle since only the feed has to be rotated. Surely the feed system of any array should be a prime consideration.

The following examples can be used as guidelines when choosing a 432 MHz EME antenna. Properly designed, these should all yield gain sufficient for echos.

1. A 15 foot parabolic dish with 55% overall efficiency.
2. An array of 16 yagis with 2 λ or longer booms.
3. An array of 8 yagis with 4 λ or longer booms.
4. A collinear array with at least 150 square foot of physical aperture and 75% minimum overall efficiency.

These are only typical examples for minimum performance. Therefore, if possible, the array should be larger to provide a greater margin of signal.

There is something magical about a parabolic dish. Many 16 - 28 footers are in use. The simplicity of a single feed is worth considering. One additional advantage of a well designed parabolic dish is that it can easily be used at other frequencies by merely changing the feed system.

The use of two inch (hole diameter) chicken wire is acceptable at 432 MHz. The wind loading is very important and therefore sturdy construction and a large strong mount are advisable expecially in snow and windy areas.

Stressed dishes have been used (Ref. 1 and 2). For strength, a hub diameter at least 15 - 20% of the dish diameter is recommended. Provisions for rear-mounted stress guys are also recommended. Recently the trussed design has been used (Ref. 3 and 4). It offers more strength and is similar to commercial construction.

F/D (focal length to diameter) ratios of 0.4 to 0.5 are recommended. Higher or lower F/D ratios generally require more complex feed systems and therefore are not recommended. The EIA reference antenna (Ref. 5 and 6 sometimes mistakenly called the NBS standard) has proven to be a good feed system for F/D rations of 0.4 to 0.5 since it has symmetrical E and H plane beamwidths of 100 to 110 degrees at the -10 dB points.

The Yagi is definitely a useable antenna. However, it should have a clean pattern (all side lobes at least 12 - 15 dB below the main beam) and a good front-to-back ratio (15 dB minimum). It also must be well-matched and have a reasonable efficiency. The best approach is to develop and measure the gain and pattern of a single Yagi before building up an array. Experience has shown that every time the number of Yagis is doubled, the gain usually only increases 2.5 dB. Therefore, plan accordingly! The spacing between Yagis is very important. If spacing is too close, the gain will be low. If the spacing is too wide, the pattern will have excessive side lobes and hence will be poor on receiving. Before stacking a Yagi, it is recommended that you review the article "Array Design with Optimum Antenna Spacing" by H. W. Kasper, K2GAL, QST, November 1960.

The W1HDQ Yagi (April 1966 QST page 20) and the WOEYE Yagi (March 1972 QST, "The World Above 50 MHz") have been the most successful . The K2RIW (ARRL Antenna Handbook, 15th Edition Page 243) is another possible candidate.

Recently the extended expanded collinear has been used to great advantage on 432 MHz EME. It is a "low-Q" structure and therefore is not as critical to construct as a Yagi array. Chief drawback is the feed system, but this is only a problem on very large arrays. A complete writeup on this design is now scheduled for publication (Ref. 7).

432 MHz offers a wide region for antenna experimentation. Unfortunately, very few commercial antennas have proven acceptable for 432 MHz EME. Therefore, one usually has to build his own. It is hoped that this writeup will assist you in your choice of a suitable EME antenna.

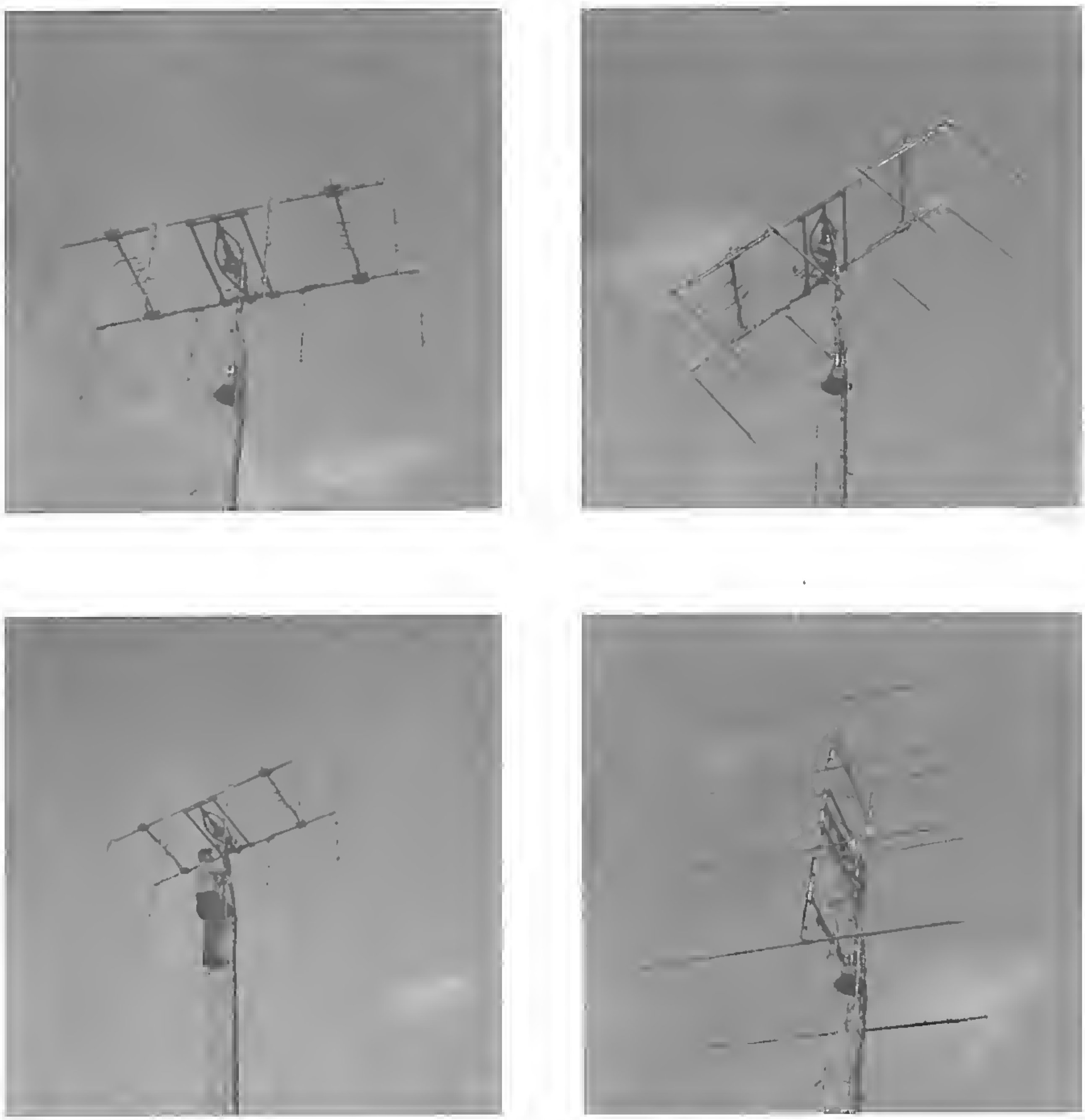


FIGURE 1

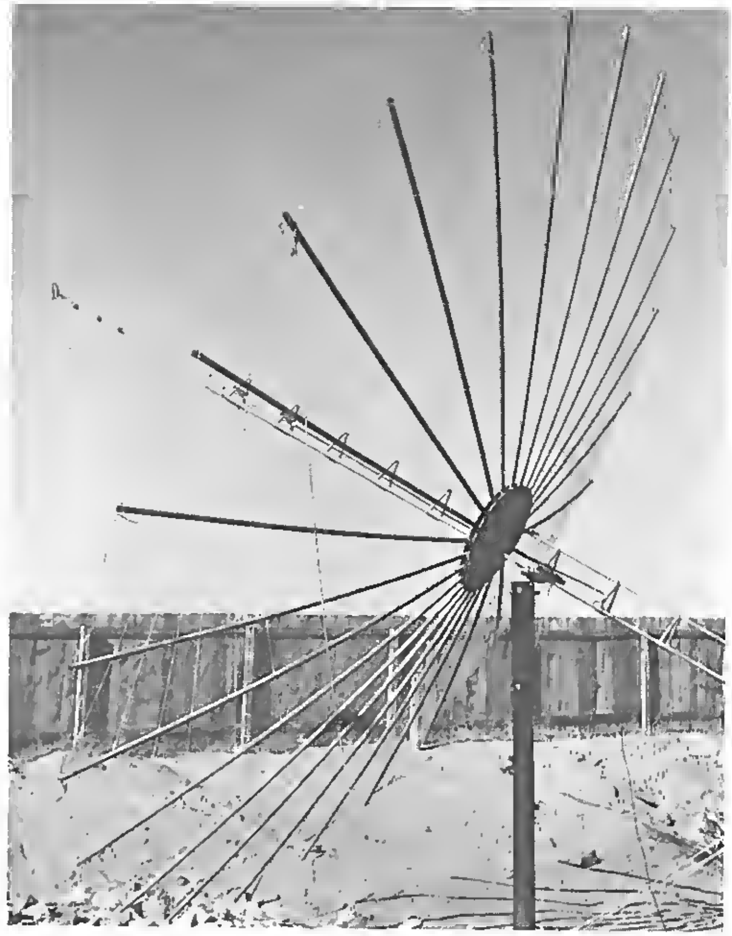
WØYZS, Mike Vestal and WAØJMC, Don Kline

This array consists of eight WØEYE type 4.2 λ Yagis (QST Jan. 1972 and Mar. 1972, "World Above 50 MHz"). They are stacked four high and two wide. Spacings are 1.6 λ in the vertical plane and 1.8 λ in the horizontal plane. The four top and the four bottom Yagis are each fed with a four-way in-phase power divider similar to the design of WØEYE (QST, Oct. 1973 "World Above 50 MHz"). A similar two-way power divider distributes the input to the two four-way power dividers. All feedlines are equal lengths of RG-8/U coax. The array is rotated both in azimuth and elevation by two standard Ham-type rotators. Gain is estimated to be 23.5 dBi.

FIGURE 2

WØOQI, Charlie Mankus

This parabolic dish should be capable of EME contacts, but has not yet become operational. It employs the stressed parabolic technique ("Simple Parabolic Antenna Design", by Katz Aug. 1966, CQ, and "A Twelve Foot Stressed Parabolic Dish" by Knadle, QST, Aug., 1972) The diameter is 24 feet with an F/D = 0.6. Each spoke is a 12 foot aluminum tube and the hub is plywood. The dish is covered with 2" hole diameter chicken wire and fed with a five element Yagi.



Some difficulties have occurred with holding the tolerances necessary. A re-design would include a larger hub made from aluminum and additional tension wires behind the dish. Gain is estimated to be 28 dBi.

FIGURE 3

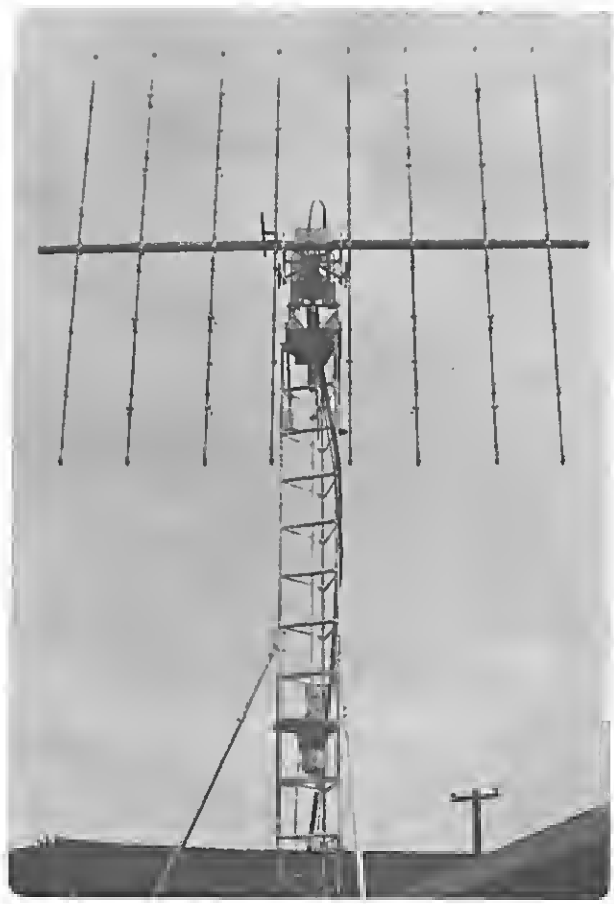
WØDRL, Al Tyler

This 20 foot dish was made from the leftover scrap of a 30 foot dish which "was large enough" and subsequently destroyed. The F/D = 0.6 and the mesh is 1" hole diameter chicken wire. The frame is 10 X 10 feet made with 2 X 4 lumber. The 18 spokes are made from 1 X 2 lumber and are partially stressed in place by standoffs mounted on the frame. Additionally, the spokes are held in shape by lines attached to the feed support. The feed consists of two $\lambda/2$ dipoles spaced $\lambda/2$ apart and $\lambda/4$ in front of a 1' X 1' reflector. A two-way power divider (WOEYE design referred to earlier) is located behind the reflector and feeds the two dipoles in-phase. The antenna is positioned manually and has an estimated gain of 26 dBi.

FIGURE 4

W6FZJ, Joe Reisert

This array is a 128 element (64 driven and 64 reflector elements) extended-expanded collinear design similar to the designs of W6GD and W6 AJF. The overall size is approximately 13 X 14 feet. All booms are 1-1/4" diameter aluminum tubing and the elements are 3/32" brass welding rods. Each group of 32 elements is fed by an "X" type feed harness of open-wire line spaced 3/4" with 1/4" diameter teflon spacers placed every 6". An "H" type feed harness distributes the power equally to the four 32 element cells. A matching stub and a 200 ohm 4:1 balun complete the feed. The array itself weighs only 70 pounds of which 40 pounds is the main boom. Gain is estimated to be 24-25 dBi. A detailed writeup on the design of this array for different sizes and frequencies is scheduled for publication in the Dec., 1974 QST.



The rotator system is three-dimensional. The polarity is controlled by a rebuilt commercial rotator. The elevation is handled by a GE motor and a three foot jack screw. The azimuth is controlled by a medium size prop-pitch motor. All axes have remote readouts with 1° calibration points. The preamplifier and antenna changeover relays are mounted at the antenna feed. This array is now operational at W6FZJ/1 in Chelmsford, MA.

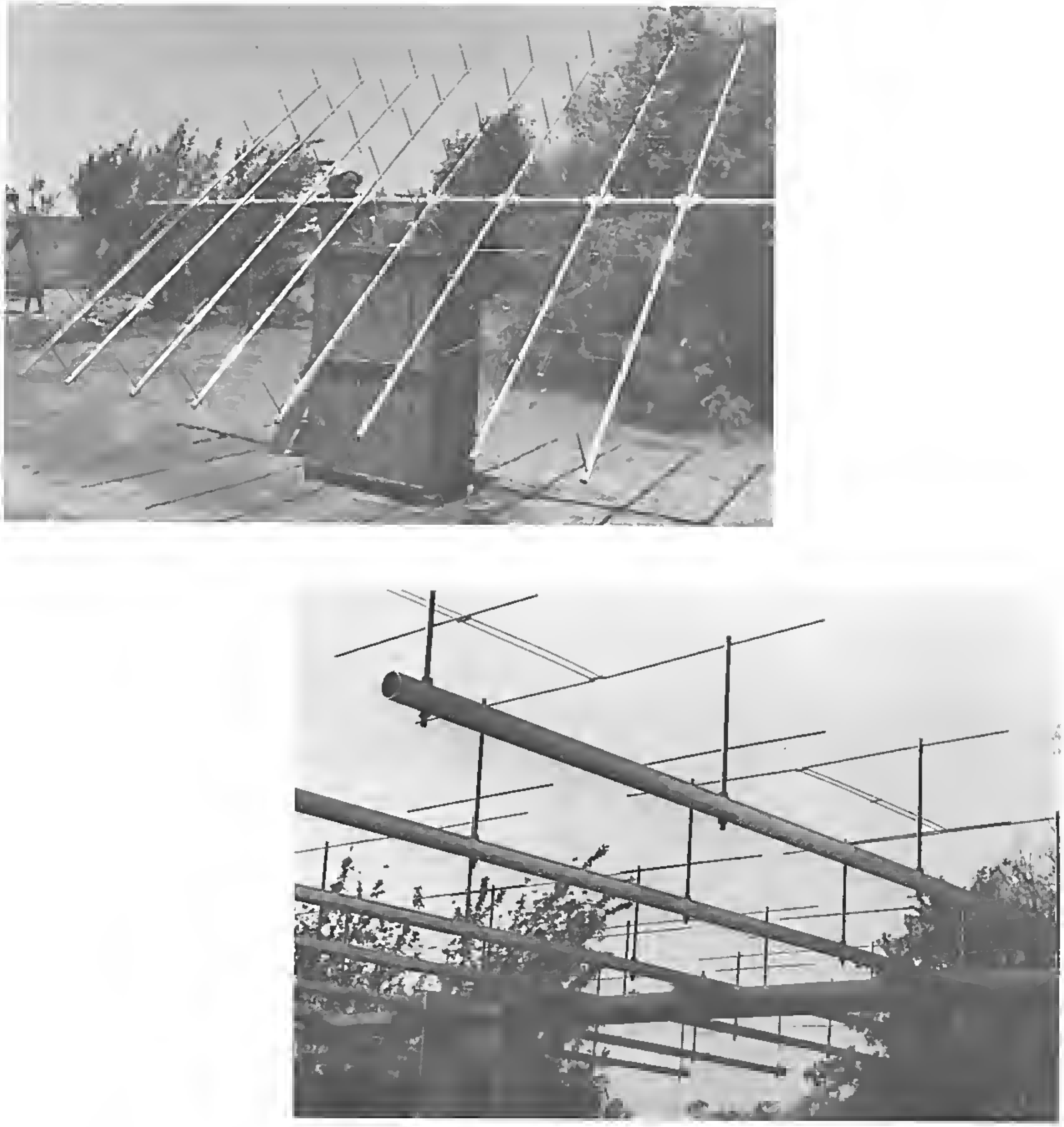
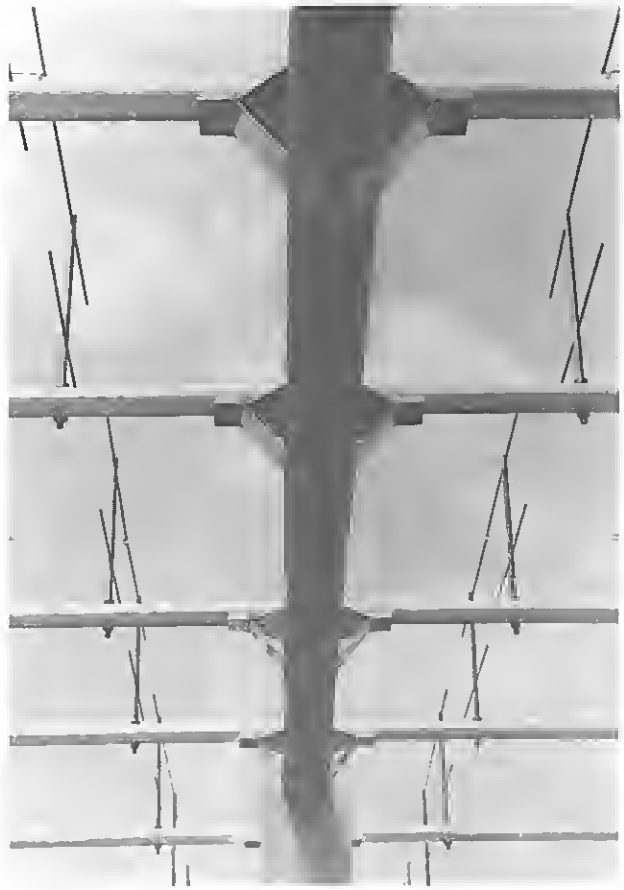


FIGURE 5

ZE5JJ, W.S. "Peter" Carey

This array is a 128 element extended-expanded collinear, following the W6FZJ design. It replaces a long (4λ X 6λ) backfire "which backfired" per Peter's quote. The jigs which were used to fabricate the array are now at ZS2A's home since he hopes to duplicate the array. The gain is estimated to be 24 - 25 dBi.

The antenna is rotated by a true polar mount. Peter is now working on an additional rotator to allow for polarity rotation. Remote indicators allow readout and adjustments from the operating position. Two cascaded preamplifiers are mounted at the antenna and drive a cable to the converter in the operating room.



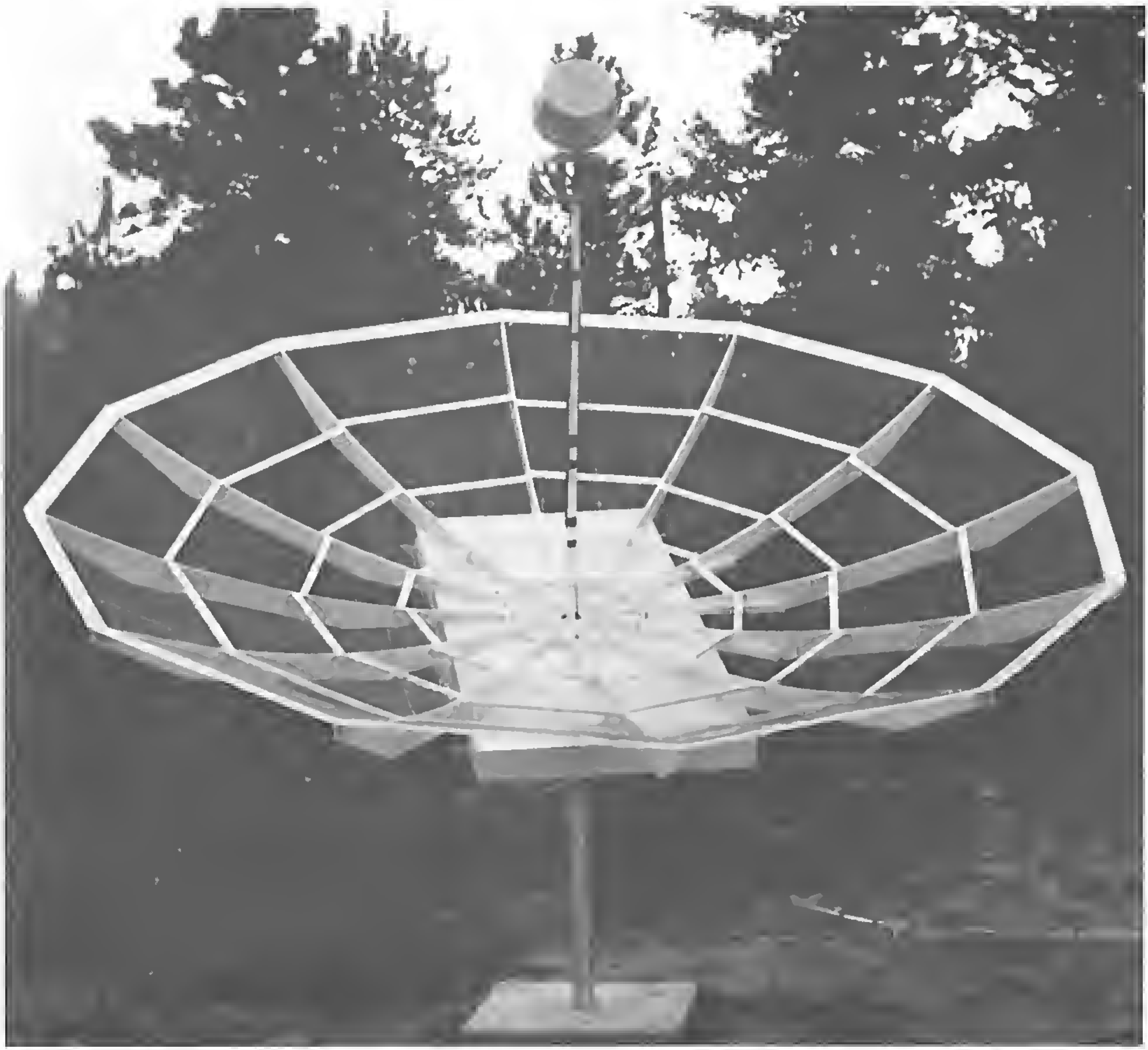


FIGURE 6

WOEYE, Don Hilliard

This 16 foot dish is made almost entirely from 4 X 8 foot sheets of 5/8" thick exterior-type plywood. The 12 ribs are cut from the plywood sheets with a skilsaw and and jigsaw. The spokes are 2" X 2" X 4'. The main hub is four feet in diameter, 3/4" exterior plywood, bolted to 2 X 8's for a supporting structure. The dish is covered with 1/2" square hole hardware cloth. Due to the complexity of using this material, Don recommends 1" diameter chickenwire for future dishes. The F/D ratio is 0.4. The feed consists of two $\lambda/2$ dipoles spaced $\lambda/2$ apart and $\lambda/4$ above a 19" X 19" solid reflector. The dipoles are fed behind the reflector with a two-way in-phase power divider. The preamplifier is mounted at the feed. Gain is estimated to be 25 dBi. Azimuth and elevation are controlled manually and directions are indicated on setting circles. Don is now constructing a trussed-rib 32 foot dish made with angle aluminum.

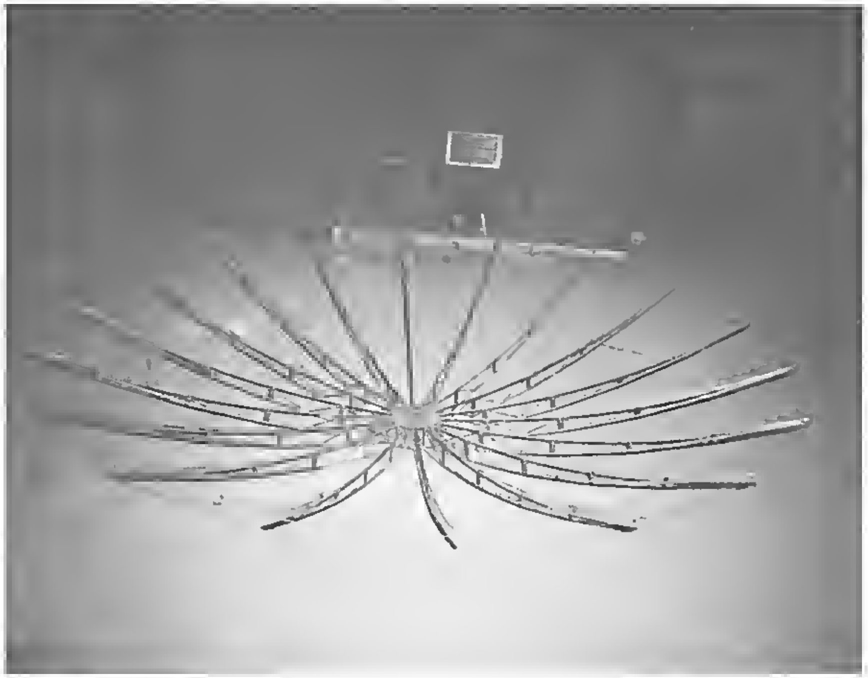
 

FIGURE 7

WA6EXV, Chuck Swedblom

This 20 foot dish has not yet been completed, but should be capable of EME communications. The entire dish is fabricated by welding ordinary 1/2" EMT tubing (available at electrical supply houses) in a trussed-rib design. The hub is 16" in diameter and six to eight inches thick. The weight including feed holder is estimated at 375-400 pounds. The covering will be 1/2" square (#19) galvanized mesh available from Montgomery Ward. The F/D ratio is 0.5 and the tolerance of 1/8" overall should make operation possible to 2.4 GHz or above. An EIA type feed is planned for 432 MHz and a dual mode (W2IMU) feed for 1.3 and 2.3 GHz. Gain at 432 MHz is estimated to be 26.5 dBi.

The dish mount is particularly interesting. The tower also houses a complete ham-shack for EME operation. Azimuth rotation will be controlled by a prop-pitch motor. Elevation uses a 1/3-horsepower motor driving a 36" diameter gear. The polarity will be accomplished by a 1/10-horsepower motor which will rock the entire dish $\pm 45^{o}$. Readouts are highly precise, 1:1 and 36:1 synchros which are capable of $\pm .05^{o}$ accuracy.



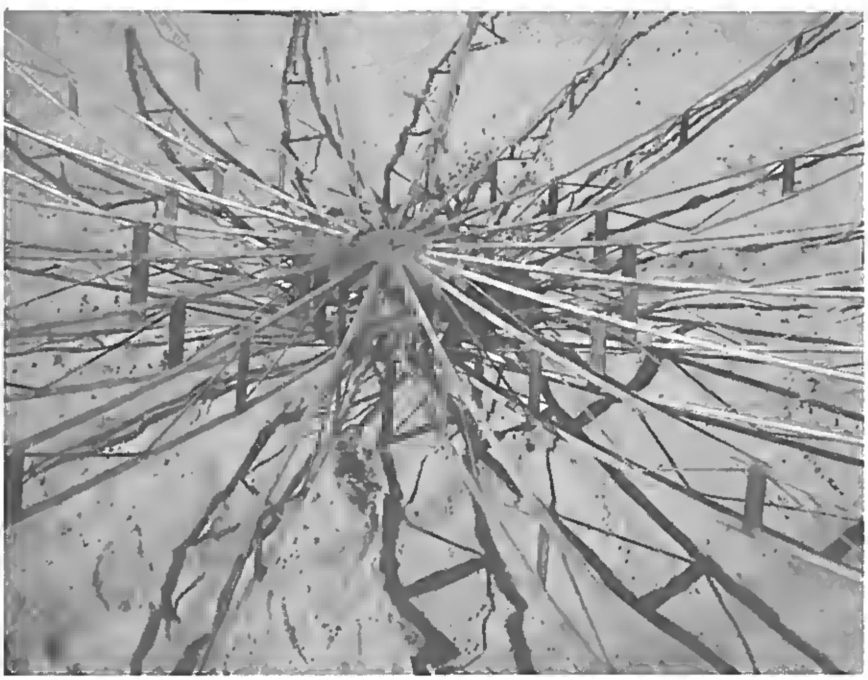


FIGURE 8

VE7BBG, Cor Maas

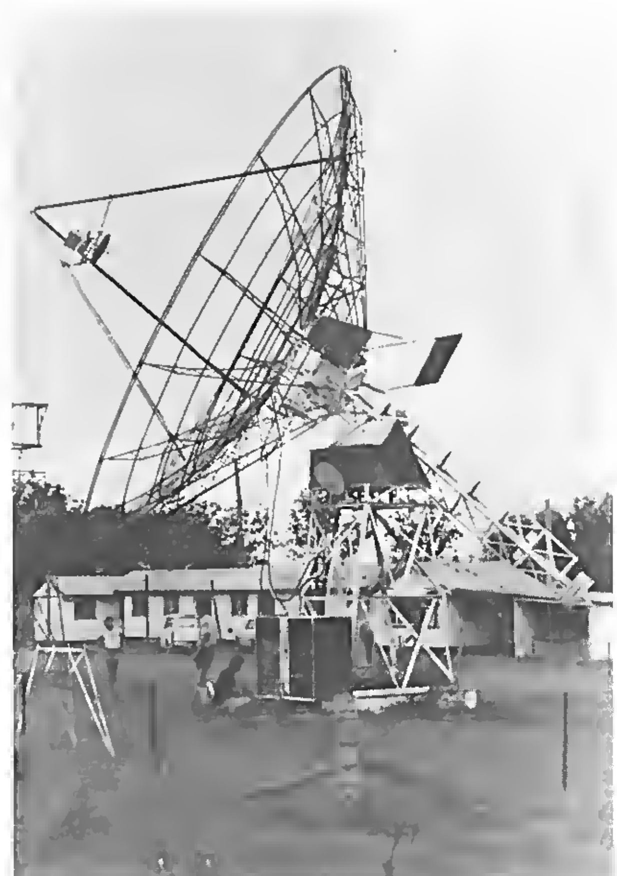
This 20 foot dish was made in Cor's basement. The ribs are made by splitting ten foot lengths of 2" X 4" spruce lumber. The finished ribs are varnished and partially held in place by nylon tension lines which also hold the feed structure. The F/D ratio is 0.5 and the dish is covered with 2" diameter chicken wire. The feed system is a dipole with a "beer can" type balun $\lambda/4$ in front of four $\lambda/2$ reflectors in the reflector plane. The preamplifier is located behind the feed. The gain is estimated to be 26.5 dBi. The dish is rotatable in three planes. The rotatable tower drives the elevation. A TV-type rotator turns the feed for polarity adjustment. All rotations have remote indicators in the operating room. This wooden dish was three years old and recently discarded when Cor moved to his new QTH. He now is operating a 20 foot all-aluminum dish and promises information shortly on its construction.

FIGURE 9

VK2AMW/VK2ALU, Lyle Patison

This dish is located at the University of Australia and is operated by VK2ALU with the call sign VK2AMW. The diameter is 30 feet and the F/D ratio is 0.4. Originally this dish was fed with crossed dipoles in front of a plane reflector. A Quadrature (90°) coupler was used for circular polarization. However, no one else on 432 MHz had circular polarization and therefore a 3 dB penalty was incurred. Recently, change-over relays were installed. One of the dipoles is selected for transmitting. Then during receive, either dipole can be selected for best results. This allows more flexibility to counteract Faraday rotation on receiving. Gain is estimated to be 29 dBi.

The dish is mounted on a true polar mount. Remote readouts allow in-the-shack control and readout.



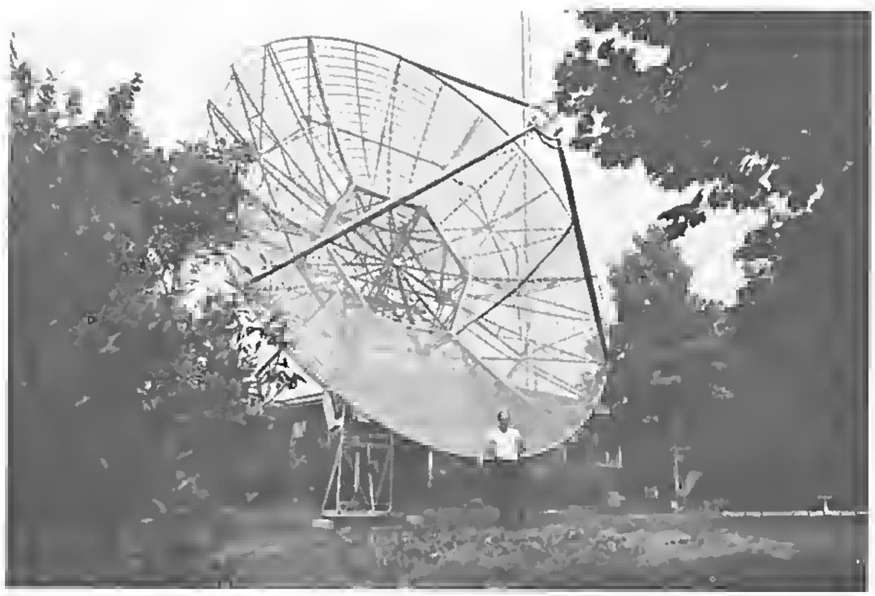


FIGURE 10

K2UYH, Allen Katz

This 28 foot dish replaces a 20 foot stressed-type dish formerly used by K2UYH for EME. It is a Kennedy-type which was saved from destruction by W2IMU when he saw Bell Labs cutting it up for scrap! The F/D ratio is approximately 0.4. The feed is similar to the EIA feed, two $\lambda/2$ dipoles spaced $\lambda/2$ apart and $\lambda/4$ in front of a plane reflector (this one is slightly less than the normal 1λ X 1λ reflector). Azimuth, elevation and polarity rotation are employed. The tower is turned for azimuth rotation. Gain is estimated to be 29 dBi on 432 MHz. This dish has also been used on 2304 MHz EME.

FIGURE 11

W9WCD, Geo Komadina

This 16 foot dish was salvaged from Collins Radio Co. The F/D ratio is 0.35. The feed is a modified VE7BBG type using a director, a balun-fed dipole and four reflectors in a plane. Gain is estimated to be 25 dBi.

The dish is rotatable in azimuth and elevation by motors. A bore-sight tube is used to aim the dish. This dish has also been used for 1296 MHz EME.

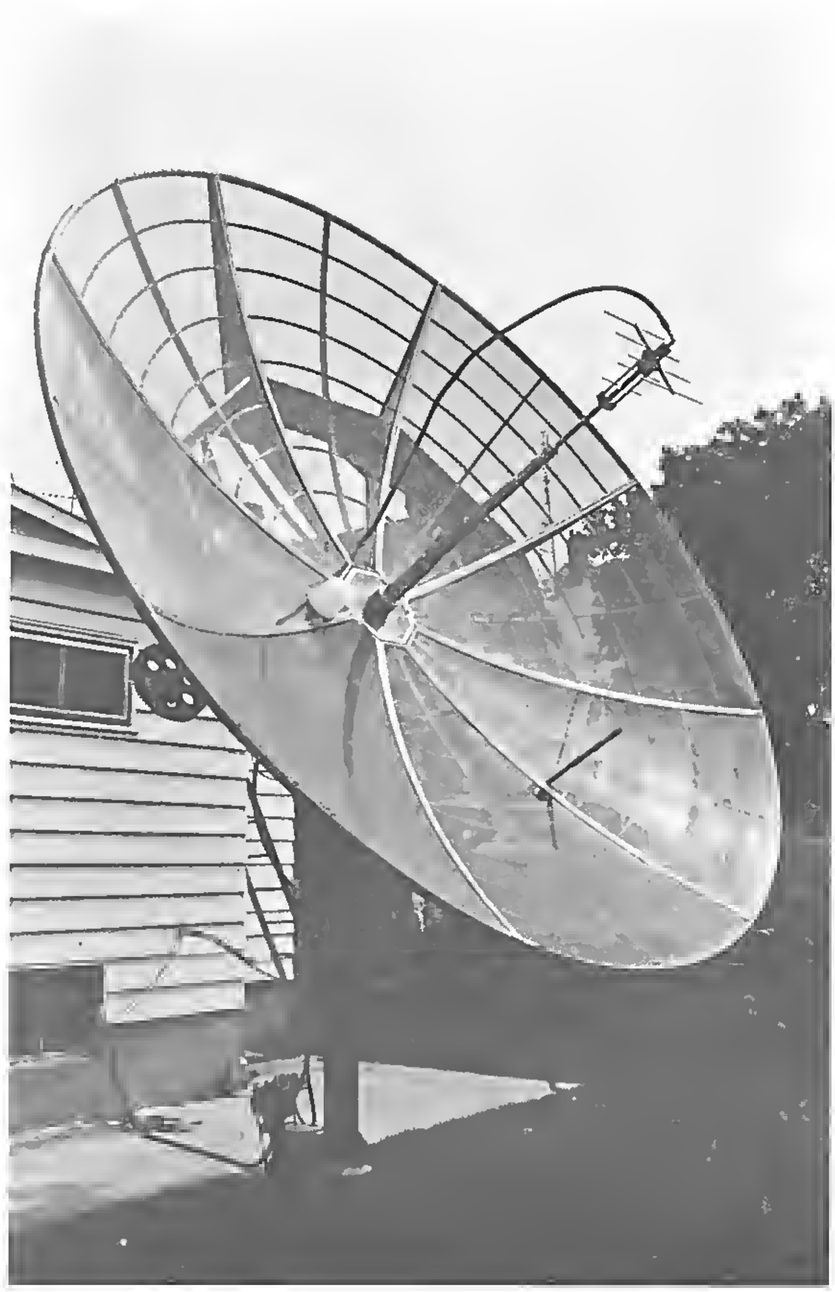


FIGURE 12

W4NUS, Guy Titman

This array is a 128 element (64 driven and 64 reflectors) extended-expanded collinear. It comprises four 32 element sections per W6AJF in "VHF for the Radio Amateur" (Cowan Pubs). Each section uses an "H" type feed harness made with 300 ohm twinlead. A similar feed harness feeds the four 32 element sections. The overall size is approximately 12 X 15 feet and the gain is estimated to be 23 dBi.

The array is rotatable in azimuth and elevation and is also used for tropo work. Stacked two meter Yagis and a 32 element 1296 extended-expanded collinear array are also sharing the same azimuth rotator. Remote indicators complete the set-up.

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7. "High Gain VHF/UHF Antenna Arrays", J. Reisert, W6FZJ, QST, Dec, 1974